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AUTHOR McBride, James R.
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ABSTRACT

A pilot study of a computerized adaptive test of mathematics achievement was conducted in May and June 1989 in selected schools of the San Diego Unified School District. The study evaluated the usefulness of the test for determining eligibility for Chapter 1 programs in mathematics. The test was a prototype battery of three adaptive tests: (1) Concepts of Number; (2) Computation; and (3) Applications. It was designed for Apple series computers for administration to students in grades 4 through 7. Each student took three 5-item adaptive tests. The pilot study of the developed test, the Stanford Adaptive Math Screener, involved 1,709 students; 1,504 also took the Comprehensive Test of Basic Skills for comparison. Overall, the eligibility determinations made using the two tests were in agreement in 80.5% of the 1,504 cases. Agreement varied from 78.6% in grade 5 to 82.3% in grade 7. The results indicate that, despite its short length, the Stanford Adaptive Math Screening Test is suitable for use in the San Diego Unified School District. Five tables present comparisons of the two tests. (SLD)

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A Computerized Adaptive Mathematics Screening Test: A Pilot Study

James R. McBride
The Psychological Corporation

California Educational Research Association
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A Computerized Adaptive Mathematics Screening Test: A Pilot Study

James R. McBride
The Psychological Corporation
1250 Sixth Avenue, San Diego CA 92101

This report presents a summary description of a pilot study of a computerized adaptive test of mathematics achievement, conducted in May and June 1989 in selected schools of the San Diego Unified School District.

The report consists of five short sections. The first section contains background information on the purpose of the study. The second section describes the computerized adaptive test. The third section presents details of how the study was conducted. The fourth section presents the results, which compare the computerized adaptive test with the printed tests now in use. Finally, the fifth section discusses the implications of the study for determining students' eligibility for Chapter 1 programs in mathematics.

1. Background: Determining Chapter 1 Eligibility in Mathematics

The purpose of the study was to evaluate the usefulness of a computerized adaptive mathematics test for determining eligibility for Chapter 1 programs in mathematics.

The San Diego Unified School District assesses certain students to determine their eligibility for Chapter 1 programs. Chapter 1 assessment takes place in reading and mathematics. In the district, a student is considered eligible for Chapter 1 programs if he or she scores below the 50th percentile in reading or mathematics on a nationally standardized achievement test, the Comprehensive Test of Basic Skills (CTBS).

The eligibility determination is based on the student's current scores on the battery of CTBS Form U tests. If no current scores are available, as in the case of a student transferring from another district, a special assessment is conducted, using an abbreviated test battery. In the case of mathematics, this special assessment uses only the computation subtest of CTBS Form S; the computation test contains 40 items, and takes approximately one full class period to administer. It uses 1973 norms, in contrast to the more recently normed Form U. Since the Form S Computation test score is used as a substitute for the Form U Total Math score, the degree to which those two scores are correlated is of interest. Column A of Table 1 contains the corelation coefficients reported in the CTBS Form U technical manual (CTB/McGraw-Hill, 1982).

The district would prefer a shorter test with more recent norms for this special assessment, and would also prefer it to cover two areas of mathematics in addition to computation: concepts of number and applications. However, these two goals -- brevity and broader coverage -- seem mutually contradictory, since additional test content would be expected to make the special assessment take more time, not less.

The technology called computerized adaptive testing has the potential, in principle, to achieve these dual goals at once. This is because adaptively

administered tests are much more efficient than conventional tests in which the same test items are given to all examinees. Research has shown that a well-designed computer-administered adaptive test can attain an acceptable level of precision in less than half the length of an otherwise similar conventional test.

District officials, aware that The Psychological Corporation had previously developed computerized adaptive tests of aptitudes and mathematics achievement, invited the company to develop and try out a short, adaptive mathematics achievement test that might be useful as an alternative to the relatively long computation test now used for special assessments of Chapter 1 eligibility. The Psychological Corporation accepted the invitation, and in May and June 1989 several San Diego elementary, middle, and junior high schools participated in a pilot study of the adaptive math test.

2. The Computerized Adaptive Mathematics Test

The test prepared by The Psychological Corporation is a prototype battery of three adaptive mathematics tests: Concepts of Number, Computation, and Applications. It is designed to operate on Apple // series computers, and is suitable for administration to students in grades 4 through 7. Its test items are taken from the mathematics tests of the Stanford Achievement Test series, seventh edition (Adaptive Stanford; The Psychological Corporation, 1982); items from five levels (Primary 2 through Advanced) of Adaptive Stanford are included.

Each student takes three 5-item mathematics adaptive tests, for a total of 15 items per student. Each student's test begins at a difficulty level appropriate to grade level. After that, the items are chosen one at a time, based on performance. The outcome of the test is a Total Mathematics scale score representing the examinee's overall performance; a percentile equivalent and NCE score are also reported.

Although the entire battery of three tests is just 15 items long for each examinee, the efficiency of adaptive testing is expected to make the Stanford Adaptive Math Screener equivalent in precision and reliability to a much longer conventional test -- one consisting of 30 to 37 items. Consequently, the Stanford Adaptive Math Screener is expected to be almost as reliable as the 40-item math computation test currently in use for special assessments of Chapter 1 eligibility. In addition, it has the advantage of basing its assessment on all three content areas, including not just computation, but concepts and applications as well. In short, the Stanford Adaptive Math Screener is well suited to meet San Diego's requirement of a shorter math screening test that covers all three content areas.

3. Overview of the Spring 1989 Pilot Study

The purpose of the pilot study was to test the technical adequacy, administrative feasibility and acceptability of computerized adaptive testing for Chapter 1 eligibility. The test of technical adequacy was done by comparing the Stanford Adaptive Math Screener with the CTBS Form U Computation test, in terms of correlations with a criterion measure and agreement on Chapter 1 eligibility. Administrative feasibility and acceptability were determined by first-hand observation of the computerized test administration, by survey of the examinees, and by feedback from teachers and administrators involved in

the study. This report covers only the technical aspects of the study.

Ten schools participated in the study. In those schools, a total of more than 1,700 students in Grades 4 through 7 took the computerized adaptive test; time permitting, the students also answered a survey questionnaire presented on the computer screen at the end of the test.

The participating schools had administered the entire CTBS Form U test battery to their students two to three weeks previously. Consequently, two sets of mathematics test scores were available for most of the students: Total Math scale scores from the Stanford Adaptive Math Screener, and CTBS scale scores and percentiles on Computation, Concepts/Applications, and Total Math. A total of 1709 students completed the adaptive tests; of these, 1504 also had completed the CTBS math tests.

These data were analyzed in order to compare the effectiveness of the Stanford Adaptive Math Screener against the CTBS Computation test. The principal analyses focussed on two outcomes: the correlations of the Adaptive Stanford and CTBS tests with a criterion score, and the degree of agreement between them on Chapter 1 eligibility classification.

For the correlational comparison, scores on the CTBS Concepts/Applications subtest were used as the criterion measure. This was chosen as the criterion because it was the only available independent measure of math achievement. (CTBS Total Math scores are not independent, since the CTBS Computation test score is a component of CTBS Total Math.) Correlational comparisons were made at each of the four grade levels, and for the entire examinee group combined. Correlations of the Stanford Adaptive Math Screener and the CTBS Total Math scores were also computed.

Before Chapter 1 eligibility classification agreement was evaluated, the Adaptive Stanford scale scores at each grade level were converted to the CTBS Computation score scale, so that the eligibility decision would use the same yardstick for both tests. Following that, classification agreement between the Adaptive Stanford and CTBS Computation was done by counting the number of students above and below the critical score on each test. These agreement frequency counts were made for each grade level, and for all grade levels combined.

4. Results

As mentioned above, complete Stanford Adaptive Math Screener and CTBS mathematics test scores were available for 1,504 students in the study. For those students, the correlations among Adaptive Stanford and CTBS Total Math scores are shown by grade level in column B of Table 1 below. (For purposes of comparison, Column A contains the correlations of CTBS Form S Computation scores with CTBS Form U Total Mathematics scores, as reported in the CTBS Form U Technical Manual.)

Table 1

Correlations of Present Test and Adaptive Stanford
With CTBS Form U Total Math Scores

Grade	Present Test: CTBS Form S Computation	Stanford Adaptive Math Screener
4	.78	.70
5	.74	.77
6	.73	.69
7	.71	.73
All	n/a	.80

Note: These CTBS Form S vs. Form U correlations were reported in the technical manual for CTBS Forms U and V. The Stanford Adaptive Math Screener correlations were observed in the pilot test.

The results of the direct correlational comparison are shown in Table 2. Here, the CTBS Form U Concepts/Applications scale scores serve as the criterion, and its correlations with CTBS Form U Computation and Stanford Adaptive Math Screener scores can be compared by grade level and overall.

Table 2

Correlations of CTBS Computation and
Stanford Adaptive Math Screener Scores
With the Criterion Score (CTBS Concepts/Applications)

Grade	CTBS Form U Computation	Stanford Adaptive Math Screener
4	.67	.67
5	.70	.73
6	.65	.64
7	.64	.73
All	.76	.77

Table 3 contains the summary statistics on the Total Math scores for both tests: means, standard deviations, and sample sizes for each grade.

Table 3

Summary Statistics:
Stanford Adaptive Math Screener and CTBS Form U
Total Mathematics Scores

	CTBS		Stanford Adaptive		
Grade	Mean	SD	Mean	SD	N
4	676	35	619	34	267
5	693	24	647	36	327
6	713	23	669	36	340
7	725	21	684	37	540
All	707	31	661	43	1504

Because the scale score means for the two tests are noticeably different, a linear transformation was used to convert the Adaptive Stanford scale scores to the same scale as the CTBS scores. Following that, the agreement between them in determining Chapter 1 eligibility was computed, using the standard then in effect in the San Diego City Schools. The agreement and disagreement frequencies were determined for each grade; the results are shown in Table 4.

The agreement percentages are listed in Table 5: overall, the eligibility classifications made using the two tests were in agreement in 80.5 percent of the 1,504 cases. Grade by grade, the agreement percentages were quite similar; they varied from 78.6 percent at Grade 5 to 82.3 percent at Grade 7.

Table 4

Crosstabulation of Chapter 1 Eligibility Classifications Based on the Stanford Adaptive Math Screener and CTBS Total Math Scores.

CTBS Form U Computation Classification	Adaptive SAT7 Classification	
	Below P50	P50 & Above
Grade 4		
Below P50	86	26
P50 & Above	29	126
Grade 5		
Below P50	107	30
P50 & Above	40	150
Grade 6		
Below P50	55	26
P50 & Above	41	218
Grade 7		
Below P50	98	47
P50 & Above	54	371

Table 5

Percentage of Agreement re: Chapter 1 Eligibility, Based on Adaptive Stanford and CTBS Total Math Scores.

Grade	Agreement Percentage
4	79.4
5	78.6
6	80.3
7	82.3
Overall	80.5

5. Discussion and Conclusions

The results of this pilot study are highly favorable to the evaluation of the computerized adaptive mathematics test, for the following reasons:

1) The 15-item Stanford Adaptive Math Screening Test scores correlated .80 overall with CTBS Total Math; the average correlation within grade was .74. These values compare favorably with the reported correlations of CTBS Form S Computation with CTBS Form U Total Math. In other words, the Stanford Adaptive Math Screener scores correlate almost as highly with the CTBS scores as CTBS Forms S and V correlate with each other.

2) In the direct comparison of Stanford Adaptive Math Screener versus CTBS Form U Computation, the Adaptive Stanford scores correlated as highly with the criterion (CTBS Concepts/Applications) as the CTBS Computation scores did. Thus, it appears that 15-item Stanford Adaptive Math Screener scores are no less effective than the 40-item CTBS Computation test for assessing mathematics achievement.

3) The two tests made the same Chapter 1 eligibility determinations in 80.5 percent of the cases, using the Total Math score for classification. This compares favorably with the 81.3 percent agreement computed between the two CTBS part scores, Computation and Concepts/Applications. Hence, it also appears that the Stanford Adaptive Math Screener scores are about as effective as CTBS Computation scores for determining Chapter 1 eligibility.

These results imply that despite the short length of the Stanford Adaptive Mathematics Screening Test, there is no significant technical obstacle to its use in screening for Chapter 1 eligibility, according to the criteria currently in use in the San Diego Unified School District.

REFERENCE

CTB/McGraw-Hill (1982). CTBS Forms U and V Preliminary Technical Report. Monterey, California: CTB/McGraw-Hill.